ENERGY STORAGE AND INNOVATIONS WORKSHOP

BREAKOUT SESSION NOTES

October 29 – 30th, 2015

NASA Glenn Research Center

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Materials, Components, and Subsystems – Session I

Discussion Leader: Mike Heben – University of Toledo

SUMMARY:

- Session was lightly attended by industry representatives (3). Most people in the room were from NASA.
- Industry representatives seemed to be more interested in hearing what potential requirements existed for space missions.
- Potential collaborations identified included:
    - Working with Case Western Reserve University (CWRU) and FirstEnergy on modeling and controlling grid/microgrid systems.
    - Working with industry partners via RPMI to apply rigorous qualifications and methodologies to terrestrial power components that are critical. No specific companies were identified.

A representative from a small company was interested in alpha/beta voltaics as a potential power source for low powered space applications. NASA has limited interest in this because it degrades the cells used in short-term disposable applications.

ATTENDEES:

(Note: Session was too large to capture all participant names)

DISCUSSION:

- Begin with overall introduction of breakout participants
    - Mostly related to energy storage and economic development
        - Some manufacturing and testing
- Conference looking to transform various regional strengths (science, manufacturing, etc.) into collaborative cluster
- Have discussed range of chemistries and technologies in previous day
    - Questions remain about packaging and integration
    - Incorporation into vehicles and grids, also as structural members
- Safety and acceptance also widely discussed
- Nanomaterials strong interest to academic researchers
- Magnetic materials also discussed, including regenerative braking
- Power electronics also discussed
- This discussion will bring with discussion of chemistries of various technologies
    - Chemistry of batteries

- Near, mid, long term focuses
- Si based anodes of interest
- What is chemistry closest to market and commercialization that would benefit most from state investment?
- From Yu: Li ion widely used, anode based on graphite, cathode on metal oxides, active research on cathode/anode, Si and Sn and metal oxide anodes close to realization but challenged by lifetime
    - Cathode looking in lithium metal oxides, limited materials, Li-S emerging from theory, more challenge to device fabrication and durability
        - Lower TRL level than anodes for those battery systems
- From energizer group (Matt Wendling):
    - Is BASF represented? (NO) They have significant research on electrolytes and separators. Price of separators is commoditized now, but work on high temp and lifetime is still going
        - Sandia breakthrough on cheaper version of nation
    - Primary batteries cathode active materials sometime just slightly refined minerals
    - Other materials in batteries are synthetically produced and most costly
    - Additional modeling and investigation into life cycle cost and pricing should be undertaken
        - Has this been done for secondary batteries?
- Yu: Collaboration with polymer companies (Lubrizol) work on membrane, electrolyte and separator
    - Electrode shrink/expansion may lead to conventional binder/electrolyte to not be stable
    - Chances for manufacturers to collaborate to improve materials and advance technology here
- Can speakers discuss in more detail about what problems exist and can be addressed by business related people here? - Benson Lee
- Gap in TRL between next-gen technologies and current materials
    - Mechanical stability of film materials is a challenge during charge cycling
    - Interfacial layer buildup during cycling
    - Impurities, humidity, side reactions could cause conversion of active to inactive materials
    - These challenges are keeping some emerging technologies to reach TRL 5/6 levels
    - Need portfolio of North Ohio work
- Energizer (Matt Wendling):
    - Ni-MH has issues of end-of-life considerations

            - Breakdown of batteries and disassembly to collect and process materials is a key area
            - Currently very labor intensity
            - Materials with varying degrees of value and utility, various hazards
            - Serious for electric vehicles coming off roads
            - **<u>Near term opportunity</u>**
        - Loraine County (Lisa Dell):
            - What are supply chain needs? Do we need more expertise, resources?
            - Like to see more of supply chain here in Ohio
            - What about work force gap?
                - Do we need more training or outreach?
                - Do we focus enough on technical training versus research and engineering training?
            - UT is increasing technician training
                - More local high schools
        - Beckett Energy (Jon Wikowski):
            - Third Frontier Commission was created to address some of this, but did not do enough
            - Need to identify where gaps are (example NiMH recycling)
            - We can encourage TFC to invest further in this area
        - Lisa Dell
            - Regarding third frontier (former employee there)
            - Flurry of activity in recent past, slowed with admin change
            - Commission looks for fast return on investment
            - Currently focuses of medical and electronic devices due to perception of greater short term wealth production
            - TFC thinks in timeframes of terms-of-office more than multi-year approach
            - At yesterday's session question asked about investment from corporations in areas
                - Some should do more locally
                - Problem with investing more in software and device businesses is that they can be moved out more easily
            - Incentives should be created such that it encourages the companies to stay, not just start here
    - Change conversation to packaging
        - Hermetic sealing of bricks as example
        - May make future discussions of H2 storage and generation more relevant
        - Comment (Babu Chalamala, Sandia):

        - Supply chain in US was lost over 20 years ago
            - Now in Taiwan, China, Vietnam
            - Need to return to US
        - What do we need to return (manufacturing)?
        - Need to identify where there are high level advantages to bring back manufacturing to meet competencies
    - Energizer (Shawn Nichols):
        - Manufacturing in Ashville, NC and also globally
        - No sense to make in US and ship to China and reverse
        - Compare to Tesla Gigafactory in Nevada
            - If costs can be driven down enough, can open other business opportunities to manufacturers and give further incentives to make in US since it will ship to US
        - Transportation of Li regulations are still changing
            - Adding cost to supply chain
    - Packaging is important, manufacturers taking on the burden, maybe need to improve TRL of some of these technologies
    - Comment:
        - Multifunctional batteries and structure currently at very low TRL level
        - May need to develop more solid state electrolytes instead of liquids to improve technology for transportation and other high energy density applications
        - Systems already quite complicated
    - Energizer (Matt Wendling)
        - Automated production process and high speed manufacturing expertise is highly important (and not well represented here) and is very important into improvements in packaging costs and technology
        - None of energizers mechanical engineering consultants, machine venders are local
    - Comment:
        - Role of additive manufacturing is also a consideration
        - Can we have universities better represented here
        - Other advanced manufacturing aspects
        - CWR and Youngstown as examples
    - Comment (Andrew Woodworth, NASA):
        - Consider semiconductor industry
        - Going up to 50cm wafer size
            - 5-10 years lag time just to adapt equipment to size change
        - Local manufacturers need to consider challenges

- More going to fab-less production
    - Companies do not need to buy all equipment, can go to centralized location with pooled resources
    - Used for production, not just prototype
    - Can reduce severe cost challenges to startups
- May not be fair comparison to PV, since semiconductor fab is much more complex in much smaller space
  - Comparing PV to other energy storage manufacturing may be more reasonable, high speed and reproducible
- Setting up labs and companies with new capabilities needs major investment
- Energizer (Matt):
  - Energizer has all resources discussed (dry rooms, small scale production, etc.)
  - Open for partnership for JDAs on < 10,000 production levels
  - Can partner with CSA
- Comment:
  - Production time currently about 5 seconds, but will sit in environment room for multiple days to check for shorts and other dramatic short term failures
  - Can we speed up accelerated life testing and quality control?
  - Are local universities doing this?
    - Yes, in PV
  - Currently charging cell, cycling once or twice
    - All in large, automated warehouse to identify soft shorts
  - Development of non-flammable electrolytes will help
- Comment (Jim, CSA):
  - Can help you with quality control
  - Are looking to invest in more facilities to support research and quality control
  - Can this cluster find a niche type of resource (we can then specialize in that testing)
  - Look at "New York Best" for similar type of activity
  - Already a lot of capacity exists, need to be careful where to act
- Comment (Alexis Abrahamson):
  - Also battery testing facility in Indiana
  - Local effort geared more towards moving small/medium companies towards market
  - Large company perspective needed to work with Center of Excellence
  - Would like to have discussions there

- Now we will shift to transportation considerations
    - Many regional transportation manufacturers, and are looking into newer vehicle types
        - Hard/soft magnets, power electronics are also good to consider
        - Safety, reliability, recyclability of batteries
    - Comment (Benson Lee):
        - Are recharging stations and home-gen H2 part of this consideration regarding energy storage?
            - They are a competitor, but completely different infrastructure
            - Infrastructure of EVs is significantly different than for H2
            - PV went through similar issue about do we want to source locally
            - Vehicle energy storage and home storage cooperation
    - Comment:
        - Push for more EV (including for aero), more weight for cables and other systems is significant
        - Planes currently can have over 1 ton of cables and similar materials
            - More research on improving weight here is important
        - Also, price of Li may not be sustainable
            - May we should focus more on Na based battery chemistries
        - Li may offer better energy density, but may be too costly
    - Comment:
        - We are in a region of strong hybrid electric aero technology
            - Very niche
        - Can we tap into this in any additional ways to leverage
            - Possibly other type of transportation besides automotive
        - Different challenges in different niches
    - Comment (Wu, OSU):
        - Integrating new battery technologies into power electronics is an interesting opportunity
        - Johnson controls is an example
- Specific recommendations for next steps
    - More than just "have another meeting" or add more people
    - Comment (Frank, UT):
        - Ohio has high density of specialists here
        - Need to focus more on federal funding and opportunities
        - Need to have faculty members more engaged
    - Near term opportunities:
        - Recycling was previously mentioned
        - Comment (Jon, Beckett & Frank, UT):

    - Funding should be on both state and federal funding
    - Third Tier Frontier is winding down
        - Do we need a new program or a renewal of TFC?
    - Need to identify critical areas for research and can have joint state and federal funding
        - TFC was geared to put out a specific product or something that would create immediate jobs
    - Recent FRN resources developed in Ohio could be used here
- Comment (Lisa, Lorraine county)
    - TFC does not see research leading to near term commercial outcomes
    - Need to clearly identify what is needed and what immediate results will occur
    - They have ~ $350M remaining and will focus mainly on entrepreneurship and manufacturing, some on internships
        - Not much on research
        - Mainly want IT and devices
            - Angels and VCs taking a similar stance
    - Some talk has begun about another round of third frontier funding, but will require public voting
- Comment:
    - If you have Ohio-based company coming to admin and stating what is needed, it is easier to receive support
- Comment:
    - Should not focus on specific device type or application for this cluster, but should work on improving advanced and agile manufacturing capabilities that can be used for multiple efforts
    - Use what is here already
- Need to highlight core competencies but also improve cooperation
- Comment (Gilles):
    - Are transportation applications the niche we want to pursue explicitly?
    - Majority of participants concur that transportation energy storage is important and beneficial to cluster
        - Not very strong on whether region has a strategic advantage here
        - Difficult for many here to say what the strategic advantage is without more information
- Comment (Alexis)

  - We have niche on transportation side, but we have grid competencies as well
  - We have programs and funding given now, need to consider and discuss what is next
- Comment (Frank):
  - Number of technical and economic personnel here
  - Need to identify both technical and economic challenges and opportunities

Space Applications and Systems – Session I

Discussion Leader: **Kevin Carmichael – NASA Glenn Research Center**

SUMMARY:

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- Industry representatives seemed to be more interested in hearing what potential requirements existed for space missions.
- Potential collaborations identified included:
    - Working with Case Western Reserve University (CWRU) and FirstEnergy on modeling and controlling grid/microgrid systems.
    - Working with industry partners via RPMI to apply rigorous qualifications and methodologies to terrestrial power components that are critical. No specific companies were identified.

A representative from a small company was interested in alpha/beta voltaics as a potential power source for low powered space applications. NASA has limited interest in this because it degrades the cells and is only useful low-power, short-term, and disposable applications.

ATTENDEES:

(Note: not all participant names were captured)

1. Kevin Carmichael
2. Randy Furnas
3. Mark Haberbusch
4. Roshanak Hakimzadeh
5. Haresh Kamath
6. Vadim Lvovich
7. Diane Miller
8. Michael Piszczor
9. Marija Prica
10. Concha Reid
11. James Soeder
12. Laurie Stauber
13. Joseph Waligorski

DISCUSSION:

- Building on connections between companies and NASA
- Bob Zephandel of Case Western Reserve Universities (CWRU) electrochemistry department: electrochemistry may solve global warming issues by replacing fossil fuels – Richard
- Water discovered on Mars, but doesn't flow often – Diane Miller
- NASA interested in generating power on the surface of Mars particularly for mining – Kevin Carmichael

- Planet-wide dust storms prevent photos being taken; nuclear power is considered but it is expensive and multiple failures may occur; solar power and energy storage in fuel cells as alternative, redundant power sources – James Soeder.
- Unused fuel on landers may be used to power fuel cells to generate power for unmanned operations – Kevin Carmichael
- Resources sent out years in advance; desirable to minimize mass, therefore, produce fuel for return on planet, take hydrogen or break down subsurface water for example – James Soeder
- Wind power generation not considered due to thin atmosphere – James Soeder
- May possibly be subsurface water that could be extracted on Mars. Thin atmosphere may also complicate pulling oxygen from the atmosphere – James Soeder and others
- Using fuel cells to create oxygen or remove carbon dioxide on the way to Mars. No questions – Kevin Carmichael
- Solar is a strong possibility; manned missions require a large amount of power; while rovers would require solar, but dust storm would cause a need for storage; power density is an important factor; redundancy using both solar and nuclear is needed – James Soeder
- Vehicles, landing system, and transit vehicles would require a similar redundancy – James Soeder
- Automatic control systems for monitoring and managing power – Kevin Carmichael
- A Master controller is required, which can capture all potential situations and provide reliable software – Haresh Kamath
- Software patches often utilized in current applications such as ISS – Kevin Carmichael
- Management of solar conditions must be addressed, many of these issues are faced in terrestrial applications – Haresh Kamath
- Management of load flows require algorithm's that allow management of power sources being explored for the grid at FirstEnergy – Joseph Waligorski
- This management requires the prediction of future conditions, particularly for solar. Control the powers sources mainly controls the curtailing of energy due to voltage issues within terrestrial applications. The smaller the system (ex. nanogrids) the more complicated the controls – Haresh Kamath
- Operations of fuel cells and batteries in space: DC must be used but generally simplifies operations – Haresh Kamath
- DC used in spacecraft because the power is generated as DC. AC has been explored, but not used primarily because it requires additional load converters. 20 kHz was explored because transformers could shift voltage. Magnetics plateau after 2kHz, technical risks did not outweigh the benefits. Space technology could not be found that would allow

the current to be disrupted, but today it is not a problem. Primary distribution for a large on surface power source could us AC potentially – James Soeder.

- Not much difference between AC and DC system, but DC is generated so it can be used directly – James Soeder
- For a small rover, a radioisotope system may be used. For larger systems (multi KW), fission-based systems (sterling) are used – James Soeder
- Transformer weights vs. power converters still go with DC because high frequencies can be used and trades much more favorably – James Soeder
- Space photovoltaics are looking to use terrestrial technology due to cost – Mike Piszczor
- Cells being tested (lithium ion cells) are designed for aerospace in terms of thermal range and shock requirements to avoid multiple designs. Some cells may still require slight modifications for space applications. Ability to use basic design with some modifications may mitigate cost – Haresh Kamath and Mike Piszczor
- Water on the moon may be used to create fuel for a mission to Mars since gravity well there is lower. The moon is likely to lay an important role in providing resources to get to Mars – James Soeder
- Radiation is a huge issue regarding travel to Mars: people must be transported as quickly as possible to avoid radiation exposure. Lunar bases will need to be potentially underground to avoid radiation
- Do batteries operate differently in low gravity environments? Utilization of a gas phase complicates operation. Shape change and temperature may also introduce issues. Long-term operations under extreme conditions are required – Haresh Kamath and Kevin Carmichael
- Size ranges for energy storage – Joseph Waligorski
- The Space Station is being upgraded to lithium-ion batteries; 20% of battery capacity is used to provide a 75 kW system. Most spacecraft use moderately sized batteries. Larger systems will be required for habitats (24 kW – hrs). Energy storage requirements depend on solar availability and eclipse time (dependent on orbit, up to 3 hrs). Mars has energy storage requirement similar to those on earth. Dust storms also affect the solar availability. Therefore, a Northern location would be desirable. Flywheel designs eliminate the thermal control problems presented by fuel cells and batteries – James Soeder.
- Flywheels and fuel cells do not scale well to larger systems. Fuel cells work well for large system – James Soeder
- Small sats and cube sats present the opportunity o fly fuel cells for testing with low economic risk – James Soeder.
- It would be helpful to update fundamental designs using standards for flight qualifications process – Haresh Kamath
- NASA is interested in control of Microgrids – Kevin Carmichael

- CWRU utilizes modeling and test beds, including DC microgrids and solar panels. System parameters can be changed as well. Marija Prica

- Process improvements may introduce unforeseen complications in operations, so testing is very important in order to avoid costly complications such as unverified failures. Industry desires to emulate NASAs testing procedures for critical operations – Haresh Kamath and Mike Piszczor

- Rigorous software testing is required for space applications – Kevin Carmichael

- Initial Space Launch Systems (SLS) missions are expected to be short. Options for power generation include solar power. However, solar power is really only justifiable for longer missions where there is a need to provide power for missions that may be as long as 10 hours. Fuel cells are a potential option for 10 hour missions that may require energy response – Vadim Lvovich

- The challenge is testing the reliability of fuel cells for missions before utilizing them – Kevin Carmichael

- Power supply on Venus; very corrosive and extreme environment with a need for short mission power supply

- Conversions of space radiation to energy? Alpha/beta voltaic have been explored. However, low power-up and short-lived operation limits applications – Mike Piszczor

Aviation Applications and Systems – Session I

SUMMARY:

- Session was lightly attended by industry representatives.
- Cross-pollination of ideas was a key focal point of this group
- Potential collaborations identified included:
    - Reaching out to groups already in existence within and outside of the Northern Ohio Region.
    - Identify customers outside of the automotive and aviation areas for a more diverse group
    - Large ~ Small Company partnerships

A representative from a small company was interested in alpha/beta voltaics as a potential power source for low powered space applications. NASA has limited interest in this because it degrades the cells used in short-term disposable applications.

ATTENDEES:

(Note: not all participant names were captured)

1. David Salay
2. Robert Button
3. Fang Luo
4. Kelly Jezierski
5. Zhenhua Jiang
6. Patricia Loyselle
7. Mike Young
8. Ryan Miller
9. Herb Crowther

DISCUSSION:

- More electric aircraft
    - Electric taxi wheel
        - Regenerative braking energy capture opportunity?
- Fuel cell powered tugs at airports, taxis, shuttles
    - Develop infrastructure / charging stations
    - Creates a synergy where More Electric drives Airport utility power infrastructure
- NASA not working on advanced energy storage directly
    - Working on materials to increase power density
    - Want to collaborate with other institutions to develop complete system
    - Things that work for smaller aircraft will not necessarily work for larger aircraft and space applications
    - Need new technology for the larger aircraft
- Look to automotive industry for new technology
    - US Advanced Battery Consortium

        - Develop a similar group for aviation to develop safety, performance, and cost specifications, and certifications

    - Cost can be prohibitive for the automotive industry to develop technology to the level needed for aerospace.
    - Aerospace will need higher level of power density & reliability

- SAE working with groups to develop standards for fuel cells and batteries for automotive and aerospace.
- NASA system analysis estimates anywhere from 500 – 800 watts/Kg (need to verify with NASA rep)
- Several performance metrics currently exist, but there is no standardization for measuring how well a system meets specific needs.
    - How do we measure goodness from a systems standpoint
    - Standards are needed to create a common basis of metrics
- Use combined technology, e.g. super capacitors with battery to balance high power needs and longer term storage requirements
- Develop replaceable "black box" storage systems that can be replaced when better technology is developed
- Energy demand profiling can help establish system requirements for different applications
    - Demand may change from now when new technologies are implemented
- New ways of thinking
    - Design aircraft around advanced power systems instead of the other way around
- Collaborative opportunities:
    - Reach out to groups that already exist
        - Regional
        - State
        - National
    - Locate Customers, not just within the automotive and aviation areas:
        - Electric power tools, etc.
        - Energy Storage for structures and storage
        - Integration into structures
    - Synergy between space, aviation, terrestrial, medical for backup power needs
        - Applications will have common needs at the fundamental technology level (e.g. materials)

    - Applications will have synergies (e.g. Hybrid Aircraft will need new Utility infrastructure at airports) (e.g. Hospitals need critical power & energy storage, etc.)
  - Create/Encourage large companies to partner with smaller businesses, specifically technology startups.
    - Ohio seems to have a huge potential between National Labs, Large Industry, Academia, Small Businesses … and Aerospace, Terrestrial Power & Ground Transportation – Need to capitalize on this potential!

- Next Steps:
  - Creation of a committee to connect with and work with the developers and consumers within different industries to establish a list of needs
  - Create a venue to continue this kind of event (Team NEO to take the lead on this)
  - Share studies from NEO and from Advanced Energy Storage Systems Initiative
  - Engage regional economic development team
  - Need to engage manufacturing & manufacturing technologies in this process as appropriate
  - More collaboration between large companies and small business with linkage to the universities
    - Development of better forums to establish connections
    - Creation of a database of companies from the various organizations contacts to create a master list
    - Regular meetings to discuss the technologies and establish a working needs list
    - Reach out to the existing companies to try to get them involved. Reaching outside of the Ohio area to pull these types of companies into this regions
      - Companies that implement advanced energy systems into small planes (example)

Automotive Applications and Systems – Session I

Discussion Leader: **Gregg Peterson – Lotus Engineering, Inc.**

SUMMARY:

- Session was lightly attended by industry representatives
- Goal of 54.5 ***MPG*** average (NHTSA #) and 40 ***MPG*** average sticker (EPA #) by 2025
- Reach 60% lower marks for the EPA by 2025
- Goal of producing an electric vehicle (EV) with a 300 mile range

ATTENDEES:

(Note: not all participant names were captured)

1. Vincent Battaglia
2. Greg Bush
3. Gram Warren
4. Larry Wilkerson
5. Nicholas Asmis
6. Joe Snyder
7. Richard Medvick
8. Karen Viterna
9. Kent Kristensen

DISCUSSION:

- *Overview given by discussion leader (Gregg Peterson of Lotus) focused initially on vehicle energy requirements*
  - *Identified the parameters in the road load horsepower equation* $(1/2PCdA_fV^2+T_CW)V$ *as key elements effecting fuel economy*
    - *Cd = drag coefficient*
    - A_F *= frontal area*
    - T_C *= tire coefficient*
    - *W = vehicle weight*
    - *P = air density*
    - *V = vehicle speed*
  - *Lighter vehicles require less horsepower to achieve the same power/weight ratio as heavier vehicles*
  - *2025 Federal requirement specifies an average of 54.5 MPG (CAFÉ) and 40 MPG combined sticker FE*
  - *Industry is mandated to improve fuel economy and* CO_2 *emissions by approximately 60% by 2025*
  - *Key systems to assist in improving fuel economy in the next ten years include:*
    - *Power train*

        - *smaller engines with increased specific outputs*
        - *transmission/gearing*
        - *lubes/oils*
    - *Cd (coefficient of drag)*
    - *Frontal area*
    - *Tire coefficient*
    - *Vehicle weight*
    - *Gregg stated that a good target for EVs is to achieve a 300-mile range or near parity with fuel burning vehicles*
    - *Hybrid systems add weight and complexity vs. a pure fuel burning vehicle or an EV*
    - *10% ↓ in weight = 6% ↑ in fuel efficiency in 2025 vs. today*
    - *30% ↓ in weight = 20% ↑ in fuel efficiency*
    - *Above FE increases include a powertrain adjusted to provide the same power/weight ratio*

- *2014 hybrid and EV sales were ≈ 2.7% of the US market (450,000 sales)*

- *EV and hybrid sales limited by cost, range and increasingly more fuel efficient gas and diesel vehicles*

- *Many forecasts predict that by 2025, about 5% of all vehicles will be EVs or hybrids*

- *A key area to assist in creating an EV with a range of 300 miles is to reduce vehicle weight*
    - *Lighter vehicle weight reduces cell pack energy requirements for the same range as a heavier vehicle*
        - *Mass de-compounding effect reduces kWhs needed, which in turn reduces battery pack weight and size*
    - *Lotus presentation at a recent national battery conference showed that reducing vehicle weight is less costly than adding batteries to achieve increased range even at projected (lower) 2020 battery pricing of ≈ $100 - $110 kWh*
    - *Regenerative braking assists in extending EV range*
    - *An audience member pointed out that a recent DOE study indicated that the balance between the energy required to accelerate and maintain vehicle speed for a heavier vehicle may be offset by regenerative braking advantages ($1/2\ mV^2$) – details of this study were not available - the audience member agreed to follow up (in a post session discussion) and provide a DOE contact who could supply details of the regenerative study*

- *An audience member pointed out that even the best regeneration systems are not 100% efficient*

- *A reminder was given to the room that accelerating and maintaining speed in a lightweight vehicle takes less energy than in a heavier vehicle*

- *The thought that 300-miles may not be necessary if the daily round trip is ~40 – 50 miles. In these cases, home charging is the common method utilized*
    - *Numerous Chevrolet Volt hybrids (per Volt FE websites) average over 1,000 MPG by using home charging and driving shorter distances*
    - *Audience question: Why is there a desire for the 300-mile range? Gregg's answer: to achieve range parity with fuel burning vehicles – range is a major obstacle restricting sales*

- *The industry needs to provide a 300 mile range for longer highway trips to meet the expectations of consumers who own and drive one vehicle*

- *Key points made relative to hybrids:*

- *Volt hybrid vs. Cruz Eco manual transmission (shared Chevrolet platform)*
  - *Volt is ≈500 lbs. heavier (2016 – 750 lbs. heavier in previous generation)*
  - *Cruze Eco (manual) gets better mileage on long highway trips (per a Car and Driver comparison test of 2011 models- the 2016 model has improved highway FE when the engine is running vs. the 2011 Volt)*
  - *Volt has less storage room (10.6 ft^3 trunk vs. 15.4 ft^3)*
  - *Volt is substantially more expensive (≈$34,000 vs. ≈$20,000 for 2016 models)*
  - *Note: the Volt is an outstanding automobile which has won numerous awards for its leading edge technology; it's owners regularly report mileage > 1,000 MPG when used for short commutes and recharged daily*

- *Battery technology question was presented; is it realistic to expect by 2025 to have a $100 kWh battery cost?*

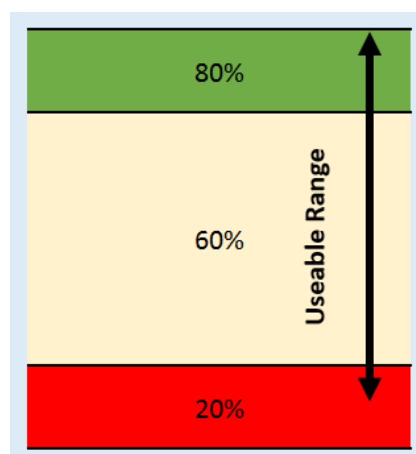
- *Battery pack replacement costs for both Tesla and Nissan (2020 timeframe) are approximately $100 per kWh*

- *Consideration should be given to reusing/recycling these types of batteries in an effort to further reduce the overall cost – audience member*

- *Battery swapping in electric vehicles is a consideration. This is an area that needs to be investigated to assist EVs in gaining parity with typical fuel stop times - audience member*
-
- *What is the life span of rechargeable batteries? After 10 years usage a typical battery pack will have approximately 80% of its original capacity - audience member*

- *Tesla is currently the only company that has used small cell batteries for an EV. Other manufacturers (and the current Tesla S and X models), use larger format batteries. The Tesla roadster, based on the Lotus Elise and now out of production, used 7,000 18650 small cell cylindrical format batteries*

- *Currently there is not very much data on the longevity of the rechargeable batteries. It is believed that used batteries can be recharged; this allows using out of warranty battery packs for secondary markets:*
  - *Mainly solar industry*
  - *Used batteries with some capacity for solar are being sold by Tesla – audience member*



- *Can the useable capacity of batteries be increased, i.e., how can we get the usable range of battery power output past 60%, i.e., max charge = 80% SOC, minimum voltage = 20% SOC.*

- *Audience responses follow:*
  - *Vary voltage to increase capacity*
  - *Tesla is currently testing increased capacity batteries*
  - *Combine different voltage batteries together in the same vehicles (devices)*

- *If battery capacity is increased what are the safety ramifications?*

- *Audience responses follow:*
  - *Safety tests show that:*
    - *Fully charged batteries are more unstable*

    - *Temperature is a factor; must find a way to keep the temperature down on a fully charged battery.*
    - *Both factors will drive battery life down and warranty costs up*

- *Due to the instability of higher power batteries, they are currently not a viable solution*

- *Lithium Ion batteries can be fully discharged and are stable for longer periods of time, unlike regular batteries*
    - *Cannot be fully discharged for long periods of time*

- *To help commercialize the electric vehicle and reduce the cost of batteries the following suggestions were provided:*
    - *Standardization of performance requirements*
    - *Develop a common language within the industry*
    - *Have a set testing standard for performance*
    - *Perform increased testing using common standards*

- *In Ohio, what is currently within the state and what is there to offer to companies?*
    - *Manufacturing is a big part of Ohio*
    - *Need to find newer methods and better ways to make batteries within the US, specifically Ohio*
    - *Better communications between industry, academia, and companies*
    - *Companies need to work together with partnering on battery technologies to reduce development costs*

Materials, Components, and Subsystems – Session II

Discussion Leader: **Robert Savinell – Case Western Reserve University**

SUMMARY:

- Materials for batteries
- Requirements for grid storage
- Safety Issues
- Standardization of cell and stack design

ATTENDEES:

This was an extremely large group and therefore a list of participants was not gathered. Names will be identified for those providing comments if available.

DISCUSSION:

(Note Taker One captured information)

- Materials for batteries are critical

- Requirements for grid storage
  - Hard to define with so many types of grid applications
  - Roughly ~ 70% round-trip energy storage efficiency required; smaller size about 200kW, ½ hours → 8 hour storage will find many applications
  - Large systems energy density about 20-40 kW hr/kg for flow batteries – Bud Baeslack

- Safety issues and environmental concerns → major and very important given the current social climate
  - Want Megawatts with multiple hours of storage of energy and especially lithium maybe of safety concern
  - Cycle Life an issue
  - Reliability an issue
  - Flow battery → anode and cathode are separated which reduces risk

- Comparators, extended life of batteries
  - Ideal Low cost materials with long cycle life
  - High power, good performance
  - Lead acid; low life cycle problem
  - Lithium-ion; limited life cycle and low rates of discharge

- Lithium-ion; may not be the best for grid application
- A general problem with energy storage is that there is not a demand to drive grid scale market
- Need stationary unit
- Large vs. micro grids
- Micro grids → changes economic cost requirements
    - Necessary for ES to be efficient
- Large kW → megawatt scale needed
-
- Upfront initial cost is a concern
    - Increasing the number of cells would increase the cost
    - Goal of one company is to reduce the number of cells
    - An asymmetric carbon- lead battery under development
        - Not for mobile applications; almost as good as lead-acid battery
        - Long life cycle
        - Good for stationary

- Basic materials need and how to help
    - Not a commonality
    - Need to find commonality/platform to take advantage of scale
    - Individual technologies would be hard to meet needs
    - Diverse stationary systems
    - Not a huge driving force because of the variety of customers
    - Carbon tax should be increased for driving stationary energy storage systems
    - Lack of storage systems to hold wind and solar energies
    - Have to keep reserve and other energy sources to meet needs when solar or wind is not being generated
    - There will be great concern when light goes off or cost of electricity goes up, so need carbon tax to drive need for stationary systems
    - Need much planning to implement

- Vanadium Systems
    - Membrane long term problem
    - Cost effectiveness very prohibitive
    - Difficult to complete, therefore not cost effective
    - DoE trying to invest and develop technology
        - Need to develop appropriate accelerated system

- Environmental effects with using vanadium
    - Toxicity issues
    - Double containment requirements
    - Assume their will eventually be some type of leakage
    - Effects of the chemical properties

    - Unlike lithium, which is closed and thin
        - When closed will let it die, but the flow systems pump let out product when open; more controlled system needed
    - Ability to slow pumps, extend discharge
        - Inefficiency of moving electrolyte
        - Flexibility is an advantage

- Efficiency; 4% - 5% loss for electrolyte pumping

- Funding sources for large scale
    - DoE Office of Electricity
    - RPE – building prototypes for industry
    - ERE by DoE research
    - Basic Energy Science of DoE

- Architecture and design
    - Commonality aspects
    - Design around characteristics of battery
    - Hard because the chemical properties are diverse
    - Company IP usually involved
    - UTRC – stacks for vanadium have been developed
    - Companies; how to design stacks
    - Companies have to design own materials
    - Give up performance to find commonality but could reduce cost
    - Ohio can and does take advantage of local manufacturing capabilities

- Vanadium Systems
    - Restricted to 40° - 60° C temperature range for flow battery operation
    - Do not want to overheat or chemicals will precipitate

- Combination of battery system
    - High temperature systems
    - FOC at 90°C and SFC at 55°C
    - Want better kinetics

- Ohio manufacturing; uses lots of carbon and Ohio has lots of carbon experts

- Carbon playing a role
    - Now in flow battery
    - Carbon nanotubes
    - Kinetics fast in flow batteries
- Ohio started the flow battery research with iron titanium then with iron chrome

- ‘74 – ‘81 was the hay day of energy-research, and when much of the early flow battery research started

- Research on reliability; what are the degradations of electrode effects
  - Unknown
  - Research needed on understanding mechanism on performance and degradation
  - Why batteries have premature fail
    - Leaks
    - Overcharging
    - Carbon electrode degradation
    - Limited # of cycles
    - Perception of chemical issues
  - Gravity assist fluid using valves instead of pump
  - Gravity fed systems are being looking into

- Iron flow battery attached to wind turbine are being studied
- Systems corrode or/and are toxic
  - Vanadium eats up plastic
  - Vanadium system have to use a strong acid
  - Limits material selection

- Small battery might use a bromine system

- Recommendations
  - Difficulties; early stages of development = low TRL
  - Less known about flow battery
  - Non-flow battery
  - Aquion energy → based on Saltwater electrolyte battery technology
    - low energy density
    - Neutral electrolyte
    - Able to use plastic which drive down the cost
  - Ohio is manufacturing here

- Flow battery; other applications
  - 100 kW, 50 kW
  - Larger capacity are being focused on
  - Proposal for EV systems
  - Into cars
    - Using car structure for electrolyte storage
  - Off and for sustained period of time
  - Safety for home owners → needed for converters

    - understand technology
- Ohio has a strong polymer industry

- Flow battery in cold environment
    - Performance in cold temperatures will need further research

- Inventory of materials for flow batteries
    - Help participating industries
    - Gaps for resources
    - Formal list of companies and industries in Ohio would be beneficial
    - What Ohio could contribute
    - Materials, test capabilities, test conditions, designs, etc. – valuable
    - Shows what Ohio has to bring – government funding
    - Suggestions:
        - Standardization of inventory
        - Standardization of materials testing
        - Standardization of life cycle testing

- Materials for electrolytes
    - Performance and materials
    - BASF – licensed Argon National Laboratory lithium electrode technology
    - Non-aqueous system – differences in system
        - Safety issue with non-aqueous solvents
        - Complexity of systems
        - High Voltage 2.5 – 3 V
            - More energy output with these electrolytes
        - Flow battery stacks with non-aqueous chemistries vs. water batteries need development

- Main Points overall
    - Standardization of cell and stack design
        - Ohio needs to take advantage of design and manufacturing industries that are low cost
    - Ohio strong polymer industry contributes to the high performing battery components and membranes.
    - Need for inventory/directory of resources to have a larger scale impact
        - Manufacturers
        - Molding industry
        - Welding
        - Plastics/polymers/membranes
        - Carbon/graphite
        - Electronics/power conditioning
        - Test capabilities

- Etc.
- Standardization of materials testing
  - Cell testing
  - Stack testing
  - Life cycle testing

(Note Taker Two-captured information)

- Grid storage applications
  - Utilities do not want to make changes because of cost. Changing infrastructure will cost money but, the upside does not seem to be that positive – Corky Thacker
  - Jeep Wrangler plant / redevelopment/ bond funded eco industrial park, create a grid off of the Eco park – Bradley Henning
  - Produce new company or something else at the Eco park – Jim Menart
  - How do we sell what we have already – Corky Thacker
  - Battery pack put out by Tesla is good. Making battery system for home without step-up/step down converter (Tesla battery). The overseas market for solar panels saves money when you do not need to put up transmissions lines – Jim Menart
  - Tax break for solar and home needs in regards to energy storage instead of returning the energy to the grid – James Gilland
  - Utilities do not like paying for the returned energy storage. Home storage helps with car charging if you had and electric car – Corky Thacker
  - Storage at home in basement without limiting size. Away to start in the market by getting prices down on solar energy kW/h. In more and more states, solar is becoming the best option – Jim Menart
  - Only a fraction of the solar cost back to the grid – Jim Menart
  - Idea #1 'Tesla battery' in home would be a starting point
  - A recycled battery from a car into homes – Dr. Fang Luo
  - Utilities not on your side with the battery – Jim Menart
  - Utilities would be interested in a micro grid – Corky Thacker

- Utilities should pay the people with batteries during peak power times and they go on battery only – Jim Menart

- Industry such as hospitals, putting secondary solar backup energy and getting away from diesel or natural gas – Corky Thacker

- Tesla battery needs cost reduction in order to work – Jim Menart

- Cluster mission should be how to drive the price down – Jim Menart

- DoE helped to drive down the price of Solar – Jim Menart

- CoE focus on bringing down cost – James Gilland

- Porous electrode increases the energy and power density. – Samak Farhad

- GLEI– Great Lakes Energy Institute is working to prioritize, connect and empower

    - Educational impact in break through discoveries. Money is a defining issue

    - Focuses on
        - Future power
        - Energy Storage
        - Solar Energy
            - Wind
            - Oil
            - Gas

    - Taking academic research strengths into commercial applications

- Real time chip integration into battery pack to convert output from DC to AC from the battery – Kent Kristensen

- Tesla's power wall can be optimized by their technology

- LG Fuel cell / venture company owned by LG & Rolls Royce – Roger McKain

- Fuel cells for microgrid interaction with energy storage capabilities so the cell can run continuously where it is efficiency is better than if they had to integrate peak performance and load sharing into the fuel cell module

- Supply Chain Needs
  - Capacitors and batteries – Herb Crowther
  - Asymmetric lead carbon capacitor
  - Technology leap – advanced materials and fabrications processes
  - Ni-C capacitor
  - Carbon nano-sphere – Western Kentucky University
  - Intellectual Property (IP) protection – Robert Savinell

Applications – Session II

Discussion Leader: Eva Gardow – FirstEnergy

SUMMARY:

- Understanding grid applications and the characterizations of the different energy storage technologies will assist in deploying energy storage systems and achieving industry growth
- Research needs to focus on:
  - putting more kWh in a smaller box with a lower price
  - Reliable energy storage system operation
- Standardization of after-market support: planned maintenance, warranties, operation surety. Guarantees are needed.
- Regulation needs to catch up with technology to provide the opportunity to use energy storage technologies in all aspects of the grid

ATTENDEES:

(Note: not all participant names were captured)

1. Ronald Rowe
2. Steve Schwartz
3. Linda Buckosh
4. John Butowski
5. Tom Stuart
6. Graham Morin
7. David Salay
8. Herb Crowther
9. Andrew Woodworth
10. Mike Heben
11. Eric Clark

DISCUSSION:

- The electricity industry does not have a storage closet. Understanding grid applications and the characterizations of the different energy storage technologies will assist in deploying energy storage systems and achieving industry growth. Most developed energy storage applications are:
  - Frequency regulation for transmission system support
  - Wind farm integration s 10 MW unit
- Regulatory and cost justification are issues that need focused attention in order to advance the industry.

- Software needs optimization

- Standardization of after-market support: planned maintenance, warranties, operation surety. Guarantees are needed, but are not quite there yet.
  - Weak points
    - Lithium batteries not lasting long → research needed, especially need frequency regulation research in order to build projects and justify

- Reliability of systems needs focus and development:
  - Silicon → cooling technology (refrigerants)
  - Voltage – balancing
  - Weak component is the PCS/electronics: Power supplies going out / how long do inverters work before replacement is needed

- Johnson Control offers BtM products that combine energy storage with their complete building energy efficiency and automation technologies
  - Will use energy storage for FR and collect associated revenues
  - JC has a project with Stanford University in optimizing energy → battery → a building system optimized with thermal loads on campus

- Potential Application: Monetizing power factored correction with storage:
  - Many issues in justification and cost
  - Sounds great, but not willing to invest due to doubt in the efficiency
  - Hard to standardize
    - Spreadsheets that analyze the numbers show a swag number
    - Commercial issues and present rates stand in the way

- Major issues in the area of reliability

- Battery technologies that should be developed and used include:
  - Flow Batteries
  - Lithium
  - Identify best uses for each battery type

- From a utility perspective, energy storage both solves and creates grid management problems. Discussion points were:
  - Electric Distribution Companies charter is to provide quality electricity to all customers
    - The paradigm is changing

  - Customers are installing energy storage systems behind the meter (BtM) for their use and to participate in RTO/ISO market programs, such as frequency regulation market, which may impact the quality of delivered electricity
    - What is the BtM installation limit and how can it be solved?
      - EPRI has been addressing this issue

- Energy Storage System product development issues:

        - Companies and vendors are developing behind the meter systems
        - Utility side product development is needed but lagging
        - Products were developed that utilities couldn't use or want to buy → moved to customer side → had to do a lot of teaching then refocused to BMS and find niche markets using as a critical backup system
            - Very difficult with niche markets
            - "Commercial inertia"

- Issues regarding advancing the energy storage industry
        - Research needs to focus on putting more kWh in a smaller box with a lower price, which will push the industry forward
        - Korea and Japan are ahead of the US, who has to catch up
        - A lot of electricity flows in Ohio and is a great place to address some of these issues

- New York Rev and California are cutting-edge for developing policy and opportunity for energy storage and in modernizing grid.

Energy Storage Systems – Session II

Discussion Leader: **Dr. Haresh Kamath – Electric Power Research Institute (EPRI)**

SUMMARY:

- Identify target applications with specificity (fuel type, size, location) for collaboration efforts
- Identify specific technical targets for said application
- Economic proposition needs to drive the decisions made
- Get younger generation involved in STEM and promote awareness
- Identify needs in the grid and opportunities for jobs within the industry
- Identify targets and give priority to what will improve the cluster. Eliminate vague purpose by having the State be specific and set achievable goals/targets
- How to implement federal environmental goals set by the EPA. These regulations by the EPA, State-by-state are followed by the companies at the state level. Tracking energy efficiency implements more renewables. The utilities are accountable so they should be approached for economic and technological needs to contribute to a clusters goals.

ATTENDEES:

- *This was an extremely large group and therefore a list of participants, if gathered, will be note in each note takers area..*

DISCUSSION:

Note Taker One

Attendees-

1. Concha Reed
2. Pat Weisel
3. Brianne Demada
4. Diana Santiago
5. Bob Draper
6. Sean Cohort
7. Dave Krause
8. Kelly Jezierski
9. Kirk Gerdes

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- Funding, economic, and administrative considerations are becoming a major consumer of time and resources at labs
- Need to identify future markets and the needs/wants of end users at outset of projects

- NextEnergy is working to match funding opportunities with organizations that can take advantage (microgrids, etc.)
  - More difficult for some small companies to work with larger partners due to IP concerns and other
  - Ratepayer interests are the main concern

- Grid stabilization is largest business are for Parker inverters
  - Partnering with renewable is increasing domestically
  - Microgrids are a larger driver internationally
  - More consideration needed into battery technology

- Challenges to reductions in fossil energy sources and build-up of renewable is causes frustrations in adaptive grid technologies
  - Move to renewable will continue regardless of opinions

- Energy storage useful for compensating for over generation
  - Already being implemented in CA, but other states looking ahead to this

- IOUs in CA proceeding with energy storage but standards are lagging behind, still under development

- New York best looking more into emergency response and grid stability/durability/reliability

- How to acquire data and understand from these changes to the grid

- How much of renewable incorporation is driven with outside funding or their money
  - Mostly their own money
  - Much of the effort is self-leading; guidance may be needed

- Are opportunities more for meeting RPS standards or for reliability concerns

- Adapting for responsibility for maintaining grid after additional outside energy added needs to be addressed

- Plans for material development for smaller/lighter is important and already underway, but immediate turnarounds are not necessarily realistic

- Fuel cell research at NASA is highly specialized (e.g. operation on Mars), but could be leveraged for grid applications

- For SBIR and STTR projects, some degree of innovation and flexibility is involved, but sill focused

- Many technologies still on the edge of high TRL levels, but too expensive

Note Taker Two
Attendees-

1. Nick Franzer
2. Frank Calzonetti
3. Diana Santiago
4. Michael Ponting

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- More collaboration between research, engineers, and industry
  - Research can be too specific and miss applications that engineers or industries desire

- Focus on Ohio's strong industry and find ways to make it stronger
  - Better understanding of where our industry will be in 20-years so we are on the same page

- Take a systems-wide approach in developing technology instead of focusing too much on optimizing sub-units or components

- Consider new applications for technology for global markets in a non-industrialized world that may be a 360° leap frog implementation in developed work with regulating off-gird technology; VAC delivery systems

Note Taker Three
Attendees-

1. Imre Gyuk
2. Lorry Wagner
3. Jim Green
4. Shawn Nichols
5. Greg Bush
6. Bob Devine
7. Enoch Nagelli

Looking for any and all considerations for grid energy storage opportunities for this discussion.

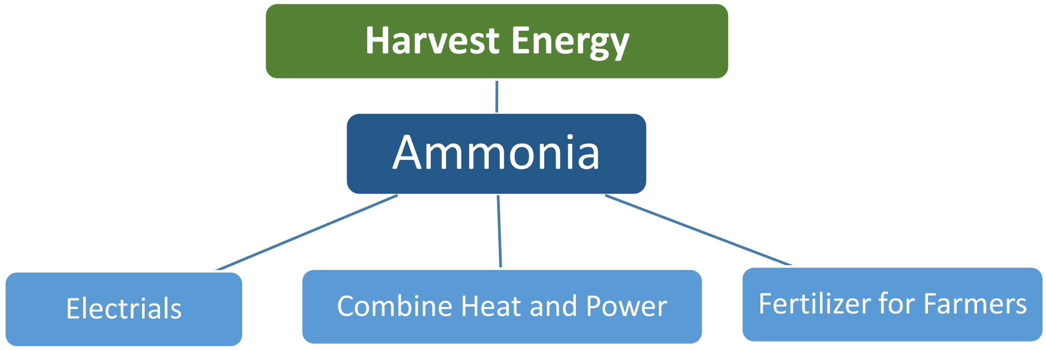
- Chemistry – explaining other chemicals
  - Nitrogen & hydrogen
  - Bring chemical companies and storage companies together
  - Flow battery
  - Use battery powered building → generates heat → use heat to heat building
  - Use abundant iron to replace expensive lithium

- Battery Power – different look start-up
  - Storing energy on solar field → 8-hours
  - Iron and water storage idea → instead of danger → rust when old
  - Want to get rid of lithium dependence → safer

- Standards, Associations, and Codes
  - A lot of questions

- Recyclability
  - End of life
  - Cradle to cradle possibility? → Shawn's company has created this ★ Retrieve → company
  - More jobs in Ohio
  - Comes down to economics → want more recyclable materials

- **Point 1:** Multi-Use Energy Storage
  - Harvesting energy for chemicals and electricity point of view to capitalize on the economic model that is holistic and that will balance to offset the prices of electricity, distribution, and the supply chain
    - Example:



- **Point 2:** Driving Safety and Regulatory Standards
  - Understand the need for standards
  - To novel of energy storage systems
- **Point 3:** Integration design for recycling in manufacturing

Other Table Ideas

- **Point 1:** Elector – Chemical located in Ohio (Parker Hannifin)
  - Localize companies to work together
- **Point 2:** Battery industry in Asia
  - Peak sharing
  - Battery uses for larger operations
  - Ice Storage → coolant at night creates ice and during the day, ice cools system for energy companies
- **Point 3:** Funding
  - Commercialization → not sure how to do it yet
- **Point 4:** Need new methods of manufacturing to beat the Chinese at manufacturing
- **Point 5:** Collaboration needs to open up to overcome IP
- **Point 6:** Micro Grid applications at home (consumer applications to bring cost down)
- **Point 7:** Utilization of the unused batteries from cars and input them into homes (consumer applications to bring cost down)
- **Point 8:** Optimize battery sub-system by brainstorming with researchers to understand what the end-goal is for a project → at the Universities
- **Point 9:** Don't miss the window of opportunity
  - Go straight to market and do not wait to get it perfect
  - Great infrastructure in Ohio already → need to make connections and partners

Note Taker Four

Attendees-

1. Mark Kilkenny
2. Nicholas Asmis
3. Andrew Jansen
4. Babu Chalamala
5. Kim Fleddermann
6. Robert Romero

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- Any applications for emerge storage systems
  - Organizations across industries

- Innovation clusters in Northern Ohio

- Industrial Infrastructure
- Lithium-ion: Who is using batteries here? Need en-item user pulling the technology to be identified
- US car industry do not care where batteries come from. There focus on whatever is the cheapest.

Opportunity for Ohio:

- Automotive follows aerospace technology and NASA can be a leader using research and applications

- Where is the center for battery/energy storage area? Midwest: Kansas, Wisconsin, PA

- Lead-acid battery production is her in US

- With increasing costs of manufacturing in China, China pushing manufacturing back to the US

- We have suppliers here: ABB and others

- What makes this region special
  - Energizers and supply chains that support them

- Neighborhood clusters sign contract
  - Have to compete against natural gas
  - Need high cycle life for grid energy storage

- Mechanical energy storage
  - Examples: recharging soldier electronics by walking

- Market in US for gird
  - Opportunity:
    - Take free energy at night and sell it the next day
    - Smart meters: tell spot price, some periods at night it can be (-), cost $ to spin down turbines

- Grid market: take energy at night and sell it in the morning when demand is the highest
  - Called "load shifting"

    - Need wind energy

- Northern Ohio is a big industry for automotive and aerospace

- Compressed air energy storage

- Need mobile back-up to the grid

- Industrial applications of power wall for industry
    - Use power wall for load shifting
    - Bring down the electric bill
    - Need to make sure battery can cycle to make up for the cost
    - Needs to be cheaper than natural gas

- Strengths in the region to pull clusters
    - Eaton, Lubrizol, Parker-Hannifin, ABB, NASA
    - Need these players at the table

- Profit to be made
    - Peaker plants get charged $ every time it is fired up
    - Want energy storage so the peaker doesn't have to be fired up for smaller demand
    - Peak shaving – need DC/AC converter

- Public/private company relationships
    - Government labs
    - University research
    - Home smart-metering
    - Peaker-shaving
    - Supercapacitors
    - Power-wall
    - Need Key players at the table
        - Government, universities, big & small companies

Note Taker Five

Attendees-

1. Elizabeth Shaw
2. Noe Alvarez
3. Benson Lee
4. Robert Lane
5. Richard Medvick
6. Dale Garret
7. Vincent Battaglia
8. Ryan Miller

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- Energizer is a major battery manufacturer in the area and should they be involved as a player at the table?
    - Invite large players into the conversation

- End-users – utilities and customers;
  - There are other storage technologies besides batteries
  - Keep in mind alternate technologies depending on the application

- Size or capability of groups – smaller than cars, automotive, grid

- Align energy applications with appropriate need. Clusters are created by looking at already existing entities in a different way

- Regenerative brakes – what relationship does this hold to entities already in place

- Bring potential competitors together to gain a leading position in the industry within Oho

- Energy storage can be aided by state inventory – EWI operates clusters as a business and have demonstrated a success in managing such cluster structures. Investigate their best practices.

- Seek large federal, small state, and private equity economic support. The cost would be $50 – $80 million to start off a cluster

- Stimulation activity has waned. Loans are now the only funds available for businesses. Grants are geared toward research

- Energy storage is part of FirstEnergy's electric grid. Storage is needed to balance the grid. Plants are more effective while operating at full-capacity

- It is expensive to shut down plants and the process can cause undue wear on parts. This is particularly useful for renewables such as wind

- Alternative to compressed air is electrolysis. Immediate needs can lead to fuel cell use. Pumping mercury up a tube for potential energy storage is another method of storage

- Commercial availability and projected cost are concerns with energy storage. Access applicability in different markets

- Public education to make consumer aware of alternative energies as an incentive for building cluster

- Identify the application that is specifically needed to put more technologies for energy storage on the grid

- Timeline for energy storage applications? There is a federal vision that has often been followed by state regulation. Fracking and coal was, and is still supported by Governor Kasich. A plan to implement a specific technology can drive the overall progress

- Water contamination drives the search for alternative energy sources opposed to fracking

- Larges lithium recycling center is being built in Ohio, leading to full participation within the battery cycle.

Note Taker Six

Attendees-

1. Mike Piszczor
2. Frank Calzonetti
3. Diane Miller

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- Main issue is consistency and reliability in space; the sun is nice and consistent

- Can easily charge batteries

- There is a huge risk in attempting new space energy storage. The cost when PV is so reliable along with battery cells

- How will Amazon use VAX – drones and what type of energy/batteries will be used

- Drones for package delivery could only be use in certain situations

- Drones are great for emergency situation.

- Fuel cells are good for long life systems but very heavy. They would not be good for flying vehicles

- US technology seems to focus on what we do and our regulations

- Other countries may be more capable of developing due to focusing on the technology not the regulations.

- Here the cell phone industries are driving PX

Note Taker Seven

Attendees-

1. Bill Hagstrand
2. James Foran
3. Tanya Linetsky
4. Karen Viterna
5. Larry Wilkerson

Looking for any and all considerations for grid energy storage opportunities for this discussion.

- What can we do?
  - We have the technology, but needs to be commercialized
    - Need collaboration with other companies – Larry Wilkerson
  - Need a like between players to get companies to work together in the most seamless way – Tanya Linetsky
  - TeamNEO exists in 18 counties within Ohio. Stretching from PA's border to Cedar Point and down to Mansfield. Working with other companies to help them grow. Connecting the dots between other companies by matching needs with companies that supply those materials/goods specific to that companies needs. – James Foran
  - Jumpstart helps entrepreneurs get their feet on the ground and to help assist in getting their business up and running. – James Foran
  - Developing electromagnetic forming at Ohio Energy. Working with the local government and funded by grants. Hoping to get to non-profit status. Needs customers to grow business in fuel cells, etc. – Larry Wilkerson

- Who are your clients?
  - People interested in the technology or someone who needs a technology developed. Startup company, very small (2-people), but large, new facility. Interested in medical devices and how their technology can help influence/change these devices. – Larry Wilkerson
  - People will go anywhere for good technology – James Foran
  - Being closer to clients helps to grow business faster – Karen Viterna
  - Should have database for region/state to make these connections easier – James Foran
  - Have wide number of new technologies that can be used and applied. Just need to get them (example: labs for testing in petroleum industry only exist in Texas.) Why not make on here in Ohio – Larry Wilkerson
  - Interested in nautical wind power. EVs, solar panels and their impacts. Wants database to make technologies searchable as was during my time with NASA – Karen Viterna
  - MAGNET has a software able to search patents to see/understand what is out there; able to tell where a new technology might be held up – Bill Hagstrand

- Scalability of batteries; can we make fuel cells/continually charging batteries able to be made on a megawatt scale? Technology is there and already exists.
  - They are just very expensive – Tanya Linetsky
  - Energy Storage/fuel cells should be thought of as collaborative – Bill Hagstrand
  - Ohio is a hot bed in this area of energy storage – Larry Wilkerson
  - Suppliers may not know the desire for their technology – Bill Hagstrand
  - Storage is abroad topic, hard to talk about specific subsystems – Karen Viterna
  - Core technology and enabling technologies both work together and depend on each other – Bill Hagstrand
  - How does this depend across the US? – Karen Viterna
  - Who owns the assets? This is how we must look at it. As an example Central Ohio has easy access to cheap energy

- Storage usually thought of as a physical device. Can also be fuel used to store energy
- Is geographically specific
- California with state regulations give credits for using certain technologies. This drives innovation and the cycle continues. There must be an incentive to get these technologies to continue to develop – Bill Hagstrand

Electrical Systems Integration – Session II

Discussion Leader: **Joe Waligorski – FirstEnergy**

SUMMARY:

- Session was lightly attended by industry representatives
- Software to Hardware one of the hardest pulls
- Major issues: reliability, capital investment and the need to regulate
- Demand response is a volatile market and forecast are unpredictable

ATTENDEES:

(Note: not all participant names were captured)

1. Kent Kristensen
2. Gregg Peterson
3. Srinivasan Vmuru
4. Justin Price
5. Neil Garrigan
6. Douglas Williams
7. Marija Prica
8. Zhyhua Zhao
9. Tom Bullock
10. Larry Viterna
11. Eileen Buzzelli

DISCUSSION:

Opening thoughts – Joe Waligorski

- Where do we see ourselves in the process/chain with respect to manufacturers, users, etc., and how do we solve these problems now or anticipate potential issues. Distribute resources by providing quality service in a dynamic method

Responses

- Good local partners
- "Billion Dollar Roundtable"
- Goal: spend billion for local businesses
- Support training for local market
- Business model needs stability
    - Utility
        - Delivery
        - Reliability
        - Quality
    - Execution
        - Operation
- How to manage grid

    - Utility Stability
        - Reliable return on energy
        - Clean energy
    - Technical aspects – connections
        - Physics
        - Model computers
    - Policy

- Challenges for energy systems:
    - Complexity
    - Battery storage
    - Renewable systems
        - PV systems microgrid
            - Hurdles
                - Policy
                - Understanding of problem
                - Safety
                - Reliability
                - Creating framework

- What does it take
    - Right business model
    - Technical vs. policy
        - Driven by funding for the technical needs

- Policy
    - Decisions made without technical knowledge
    - Technical knowledge needs to drive what furthers policy

- What would be the focus of the clusters this workshop is trying to form
    - Storage market for technology
    - Understanding what the issues are and having the cluster work to implement needs based on the technology aspect and to the manufacturing/business aspect

- What are the issues
    - Clusters implement to the technologies aspect
    - Implement to the business aspect

- Ideas for getting cluster together
    - Can design, but need the assistance of the community to install
    - Local vs. regional, and national
        - Examples- Problem in New Jersey is the same as OH
        - Cleveland
        - Northern Ohio
        - Midwest corridor
    - Extensive knowledge available within the Ohio area, should be able to find the answers here

- Is personal grid good for FirstEnergy? Is it good for off grid?
  - Primary vs. compliment
  - Transformation of grid with new renewables
    - Can be individual
    - People can go off grid
  - Reliable, safer, affordable energy

- Role of cluster
  - A continuation of U.S. here in the Ohio region

- Define cluster
  - Use of inside information
  - Product information

- The grid has changed in regards to the power sources. Now power has the addition of wind and ocean

- Manage of the grid transformation
  - Examples to view would be Germany and China

- Making clusters effective
  - Job growth
  - Focus to the areas of:
    - Northeast Ohio
    - Dayton
    - Cincinnati
    - Pennsylvania
    - Michigan
  - Build a strong customer base by networking
  - Cluster could be aligned by utility service regions
  - Understand the rule changes from service area to service area
  - Kickstart the market for storage by creating a local demand

- How to integrate utility
  - Utilities need to adopt a more friendly stance; could be a game changer
  - Utility companies to be a sponsor in the energy storage arena
  - Mechanism to spur support
  - Involvement of national laboratories; AFRL, NASA GRC, etc.
  - Synergies between transportation, energy storage and possibly hospitals
    - Mobile
    - Stationary
    - Service Utility
    - National Labs
  - Microgrids
    - Universities and other notable entities tied to the grid

- Build clusters across the regional utilities

- Cautions
  - Limits economic systems
  - Development roles3

- Energy transportation with in the Aerospace
  - Airports
  - Package in 747's
  - Changing grid

- Challenges
  - Not having context on how market works
    - Rate schedule
      - Derived from when transaction occurs
      - Reshaping energy profile- change way utility companies charge purchases
      - Stakeholders at the PUC level
        - ISO at the regional level
        - PUC at the state level
      - ISO should be a real time priority

- Cluster implementation of technologies
  - Energy storage
    - Active system controls
    - Community ISO
    - Follow Signals from ISO
  - First stakeholders
    - Align stakeholders to benefit cluster
    - Provide training to cluster members
  - Build upon base of stakeholders

- Use energy to effect change with utility companies
  - Electric Vehicles → change demand → changes way energy is purchased

- Look at rate schedule not the financial issues

- Differences across the various sectors; are they interchangeable?
  - Enlighten the stakeholder as to the market place value derived from application of technology
  - Derived
  - Bottom-up policy
  - Changing rate policy
    - Discriminate projects for rates and cost

- A cluster would create a bigger potential overall impact
  - Transport of electricity

- Role of storage
- Supply chain

- Rate Structure
  - Focus on a broader perspective
  - Fair to all
  - Policy/negotiations

- Utilities need simplification of way in which they do transactions

- Consumer Power; can benefit from ISO

- Whole Sale for ISO customers is a different market than retail

- Clusters would provide a bigger understanding of technology, technology management, and data analytics relating to the technologies

- Looking at non-utility and non-geographical in centered 1hdm homeowners

- Create a market geographically designed for the clusters demographics

- California has a 1.3 GW storage integrator

- ISO situation
  - How to encourage micro-markets
  - Leverage smart application

- Clearly define the value stream

- Distribution of technology can be a challenge
  - Pull; the marketplace (CREATE DEMAND)
    - Create marketplace successfully and rapidly
  - Push; public interest
    - Labs
    - Founders
    - Local government
  - Innovate grid
    - Not against utility's interest

- Get utility interest out of innovation

- States shouldn't regulate

- Cost recovery for customers

- California model should be reviewed

- Problem/concern raised is the net metering rates, 5-RECs
- No more think tanks funded by right wing/left wing
- Financial; legally getting in the way of engineers
- Problem – getting changing infrastructure
- Solution – battery on wheels
  - Truck electricity
  - Placement of trucks
- Shared economy by getting the electricity to where it is needed

- Distribution planning
  - Accessibility; collaboration → technology → solutions
  - Distribution planning/metering
    - E.g. wastewaters
    - Metering energy team
    - Central plan – energy heat
      - Owned by the utility companies
    - Solar meant to go back to grid
      - Forum to distribute – work with developers
    - When Push power into system
      - Dynamics
      - Grid is need to generate supply

- Cluster → Inform to policy
  - Business device access
    - Difference in business types dictates policy

- University/Academia
  - Integration of renewable power
    - Conversion
    - Control
  - Energy storage with renewables
    - Friendly to grid
  - Barriers to accommodate techonology
  - Work together on grant research
  - Cross-training – learn from industry
  - Can be a waste of students time when involving them in things that do not happen
  - Early stage projects
  - More efficient advances
  - Influence policy
  - Metering, planning → identify challenges needing to be solved
  - Universities – analysis of cost, present to those outside of the microgrid
  - University guide on policy – guide unintended policy

- Replace gas stations with power generators
  - Enough energy = truck with battery?
  - Supply enough to meet demand?
  - Lots of power – refuel cars in 10 minutes

- More electric vehicles are needed to be sustainable = convenient supply of energy
    - Example: London – taxi's and delivery vehicles are electric
        - Mandates for fuel efficiency
        - Pull – market based
        - Rapid convenient charging